



Radiative damping and electron beam dynamics in plasma-based accelerators

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Summary: full analytical description of the radiation damping in plasma-based accelerators.

Results for an e-beam:

$$\langle \gamma \rangle = \frac{\langle \gamma \rangle_0}{1 + \bar{\nu}_\gamma t}$$

$$\epsilon_{Nx} \simeq \frac{\Omega \langle \gamma \rangle_0}{c} \sigma_{x0}^2 \left(1 - \frac{5}{4} \tau \alpha^4 \langle \gamma \rangle_0 \sigma_{x0}^2 t \right)$$

$$\frac{\sigma_\gamma^2}{\langle \gamma \rangle^2} \simeq \frac{\sigma_{\gamma 0}^2}{\langle \gamma \rangle_0^2} + \frac{1}{2} \tau_R^2 c^4 K^8 \left(\langle \gamma \rangle_0^2 \sigma_{x0}^4 + \frac{\sigma_{ux0}^4}{K^4} \right) t^2$$

Example: damping length in the blow-out regime: $L_d [\text{m}] = c/v_\gamma \sim n_e^{-2} x_m^{-2} E_b^{-1}$
 $\approx \underline{6.8 \text{ m}}$ for $n_e = 3 \cdot 10^{17} \text{ cm}^{-3}$, $x_m = 10 \text{ } \mu\text{m}$ (osc. amplitude) and $E_b = 42 \text{ GeV} \rightarrow v_\gamma t \sim 17\%$ for
 113 cm plasma

Main conclusion: radiation effect can be significant with beam-driven experiments parameters (laser-driven: effects typically negligible); main effect: energy spread. Importance of the damping rate v_γ : energy decreases as $\sim v_\gamma t$, $\sigma_\gamma / \langle \gamma \rangle$ **increases (asymptotically) as $\sim v_\gamma t$** , emittance decreases as $\sim v_\gamma t$

Solution: decrease plasma density (?)

Reduces radiation: small energy loss and small increase of energy spread; but implies a **compromise with accelerating gradient** (larger at higher densities)